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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/607,838	06/27/2003	Kanakasabapathi Subramanian	1153.071US1	8463
21186	7590	01/10/2005	EXAMINER	
SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A. P.O. BOX 2938 MINNEAPOLIS, MN 55402			LUHRS, MICHAEL K	
			ART UNIT	PAPER NUMBER
			2824	

DATE MAILED: 01/10/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

<b>Office Action Summary</b>	<b>Application No.</b> 10/607,838	<b>Applicant(s)</b> SUBRAMANIAN ET AL.	
	<b>Examiner</b> Michael K. Luhrs	<b>Art Unit</b> 2824	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 12 January 2004.
- 2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-23 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☒ Claim(s) 16-20 is/are allowed.
- 6) ☒ Claim(s) 1-15 and 21-23 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 26 April 2004 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)  | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)   | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152)             |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)<br>Paper No(s)/Mail Date <u>12 January 2004</u> . | 6) <input checked="" type="checkbox"/> Other: <u>search history</u> .                   |

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### DETAILED ACTION

1. An examiner's amendment was discussed with Attorney Dahl on 12/06/04 however in light of the reference to MacDonald et. al. appearing on applicant's IDS dated 12 January 2004 the discussed amendment is withdrawn by the examiner.
2. Examiner acknowledges applicant's election of group I, claims 1-23 without traverse dated 12 October 2004.

### *Specification*

3. The specification is objected to as failing to provide proper antecedent basis for the claimed subject matter. See 37 CFR 1.75(d)(1) and MPEP § 608.01(o). Correction of the following is required:

- a. Claim 3 contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claim 2 indicates "further comprising removing the oxide", hence in claim 3 'wherein the oxide is removed' specifically 'using CHF<sub>3</sub>', is not supported by the specification, there is no indication in the specification the oxide is to be removed using CHF<sub>3</sub>, rather removal is an **optional step** in lines 5-6, [0013] and **no etchant is specified**.
- b. Claim 12 contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claim 11 indicates "further comprising removing the oxide", hence in claim 12 'wherein the oxide is removed' specifically 'using CHF<sub>3</sub>', is not supported by the specification, there is no indication in the specification the oxide is removed using CHF<sub>3</sub>, rather removal is an optional step in lines 5-6, [0013] and **no etchant is specified**.
- c. Claim 7 contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claim 7 indicates a 'deep etch comprises CHF<sub>3</sub>', there is no support of such a deep etch comprises CHF<sub>3</sub> in the specification.

### *Claim Rejections - 35 USC § 112*

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

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The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. The term "deep" in claim 7 is a relative term which renders the claim indefinite. The term "deep" is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention. The examiner has found art that indicates that a  $\text{CHF}_3$  etch can etch only to the extent of 50 um (Goldbach et. al. USPN 6,780,337, line 21, column 1), the examiner does not consider 50 um to be "deep", and therefore the  $\text{CHF}_3$  etch to be used as a 'deep' etchant is apparently inconsistent with the applicant's invention.

***Claim Rejections - 35 USC § 102***

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

7. Claims 1-6, 9-11, 13-15, 21-23 are rejected under 35 U.S.C. 102(b) as being anticipated by MacDonald et. al. USPN 5,628,917 (herein after as "MacDonald").

Regarding independent claim 1, MacDonald teaches the method of forming two level structures in a semiconductor substrate, the method comprising: forming lines of different widths having a first floor; in Fig. 1f showing different widths of p+ silicon on a p+ silicon starting substrate '10' (lines 18-19, column 5), (it has a first floor, the first floor is that area of the thermal  $\text{SiO}_2$  '18', that covers the P+ substrate, refer to Fig. 1g), oxidizing the wafer until lines of thinner width are substantially fully oxidized; the thinner width as it appears in the center of Fig. 1i, is oxidized substantially fully, (lines 55-56, column 5), etching the oxide to expose the first floor; as MIE etching of the floor silicon oxide '24' (lines 57-58, column 5) from Fig. 1i to 1j, and etching the exposed first floor deeper into the substrate to form a second floor, as etching, trench RIE step, lines 60-66, column 5, as it is shown in Fig. 1k after this etch is completed.

Regarding claims 2 and 3, MacDonald teaches an HF etch removes previously formed layers (lines 48-49, column 5) hence the oxide is removed (therefore claim 3 is treated on the merits even though claim 3 has a 1<sup>st</sup> paragraph issue).

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Regarding claim 4, MacDonald teaches the MIE with  $\text{CHF}_3$  (in line 40, column 5), and for the MIE in line 57 column 5, (this is an RIE, since 'reactive ion etch' is indicated in line 39, column 5, is considered anisotropic because RIE and the  $\text{CHF}_3$  and same material being etched, see also with high selectivity, lines 40-41, column 5).

Regarding claim 5, MacDonald teaches a p-type (100) silicon wafer '10' starting substrate (lines 18-20, column 5), is apparently single crystal as implied by the orientation (100).

Regarding claim 6, MacDonald teaches RIE etching (line 65, column 5) is considered the deep etch to extend to 100  $\mu\text{m}$ , see also 'deep' in line 33, column 5.

Regarding claim 9, MacDonald teaches the wafer is subject to oxidation: 'wet *thermal oxidation*' (lines 25-27, column 5).

Regarding claim 10, MacDonald teaches claim 10 that has similar limitations when compared to claim 1, namely the *structures* formed in the substrate, i.e. MacDonald shows *structures* formed of the substrate from Fig. 1e to Fig. 1f, and shown with different widths, the remaining limitations of claim 10 are the same as claim 1, albeit a 'next floor' as considered to 'second floor'. The citations used in the rejection of claim 1 are inclusive to this rejection, please refer back to it above.

Regarding claim 11, MacDonald teaches *removing the oxide*, as an HF etch that removes previously formed layers (lines 48-49, column 5) hence the oxide is removed, *repeating oxidation*, oxidation Fig. 1i, lines 55-56, column 5, *etching*, etching to remove '24' lines 56-57, column 5, and *etching to form a further level*, trench RIE Fig. 1k, lines 65-66, column 5, *wherein successively wider line widths are oxidized*, for this last limitation the examiner would consider that oxidized silicon would be greater in width (than at least what remained after the HF etch) and that width would affect the etching width thereafter, would therefore be at least the oxidized width, therefore considered successively wider, hence MacDonald is inherently capable of doing so.

Regarding claims 13 and 14, MacDonald teaches RIE to etch the floor, see MIE in line 56, column 5, to etch floor silicon dioxide '24', and also the MIE is reactive ion etching (RIE) as expressed in lines 39-40, column 5. This etch is in  $\text{CHF}_3$  plasma (line 40, column 5).

Regarding claim 15, MacDonald teaches that the substrate has 100 silicon wafer orientation, indicates single crystal silicon.

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Regarding independent claim 21, *the method of forming two level structures in a semiconductor substrate, the method comprising: forming lines of different widths having a first floor; MacDonald teaches lines of different widths are apparent by the Figures 1d through 1f, oxidizing the wafer until lines of thinner width are substantially fully oxidized; the thinner width as it appears in the center of Fig. 1i, is oxidized substantially fully, (lines 55-56, column 5), etching the oxide to expose the first floor; as MIE etching of the floor silicon oxide '24' (lines 57-58, column 5) from Fig. 1i to 1j, etching the exposed first floor deeper into the substrate to form a second floor; as etching, trench RIE step, lines 60-66, column 5, as it is shown in Fig. 1k after this etch is completed, and releasing the lines to form suspended structures, as undercut release of Fig. 1n (lines 4-6, column 6).*

Regarding claims 22 and 23, MacDonald teaches oxidation in lines 66-67, column 5, and isotropic etch, would be an etch in all directions, given the term isotropic. This etch is  $\text{SF}_6$  RIE as indicated in line 5, column 6.

#### ***Claim Rejections - 35 USC § 103***

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

9. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

10. Claims 7-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over MacDonald as applied to claim 6 above, and further in view of Goldbach et. al. USPN 6,780,337.

MacDonald lacks the *deep* reactive ion etch using  $\text{CHF}_3$ . (*The Applicant admits that deep RIE can be used for a deep reactive ion etch of the substrate of the etching processes listed on p. 4, [0009] lines 4-9, but fails to explicitly demonstrate the use of the  $\text{CHF}_3$* ). Goldbach teaches that the substrate can be etched using halogen

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contained gases (to which  $\text{CHF}_3$  is listed in prior art lines 18-19, column 1). Since Goldbach and MacDonald are interested in RIE of the substrate, the  $\text{CHF}_3$  would have been recognized by MacDonald for RIE etching (lines 18-22, column 1, prior art expressed by Goldbach). One having ordinary skill in the art would have looked to etchants that have been used to etch the substrate and would have found that the success of the  $\text{CHF}_3$  to be effective to 50 um deep (lines 21-22, column 1). (Claim 7 has a 2<sup>nd</sup> Paragraph 112 issue regarding depth and lacks of support in specification, yet the examiner has treated the claim 7 and dependent claim 8 below, on the merits, as best as possible).

The specifics of the  $\text{CHF}_3$  i.e. flow and pressure of claim 8, are result effective variables to optimize the use of the  $\text{CHF}_3$  etchant in claim 7, and are not patentable, because one having ordinary skill in the art would have looked to these variables to optimize the etch of the substrate for the best results. MPEP 2144.05 [R-1] II, A, *in re Aller*.

11. Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over MacDonald as applied to claim 11 above, and further in view of Groechel et. al. USPN 5,021,121. MacDonald's further removal of oxide is performed using HF thus lacks the oxide is removed using  $\text{CHF}_3$ . However  $\text{SiO}_2$  oxide removal can be accomplished using  $\text{CHF}_3$ , because such an etchant is highly selective to silicon as taught by Groechel et. al.. Since MacDonald and Groechel are interested in removing the oxide it would have obvious to one having ordinary skill in the art to look to other etchants that could be used to remove the oxide such as the  $\text{CHF}_3$  etchant taught by Groechel. (Claim 12 has a objection issue yet the examiner has treated claim 12 with art as best as possible).

***Allowable Subject Matter***

12. Claims 16 and 17-20 are allowed.

13. The following is an examiner's statement of reasons for allowance:

Regarding independent claim 16, the specific *lithographically forming a pattern having structures of different widths* and the novel step of *oxidizing structures on the substrate until lines of structures of a selected width are substantially fully oxidized*, and  *$\text{CHF}_3$  reactive ion etching the oxide to expose the first floor*, was not taught or suggested by the prior art.

Regarding independent claim 17, *the method of forming a comb actuator in a semiconductor substrate, the method comprising: having the novel step of: forming pillars of alternating thick and thin widths extending from a*

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*first floor of the substrate; oxidizing the wafer until pillars of thin width are substantially fully oxidized; etching the oxide to expose the first floor; etching the first floor deeper into the substrate to form a second floor*, was not taught or suggested by the prior art. Claims 18-20 dependent thereto are also allowed.

14. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

#### ***Conclusion***

15. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure: Adams et. al. USPN 6,797,589 teach the insulating micro-structure and the method, by filling the trenches with insulating material. Morimoto et. al. USPN 6,730,535 teach the SOI method, having support substrate intermediate insulator layer and silicon substrate (140, 141, 143, respectively, and masking 144 as shown in Fig. 13). Solgaard et. al. USPN 6,713,367 teach the combdrive actuator method of fabrication, a first comb coarse teeth, from first wafer, and bonding second wafer to the first teeth. Behin et. al. USPN 6,612,029 teach multi-layer, self aligned vertical combdrive electrostatic actuator, and fabrication, first and second are formed in a single step from a multi-layer structure. Notably a two step etch is taught by Khan et. al. USPN 6,518,192 can be utilized for MEMs. Forbes USPN 6,174,784 teaches technique for small island of silicon on insulator. Shaw, et. al. USPN 5,426,070 teach microstructures and high temperature isolation process (and complete thermal oxidation, line 8 "Abstract"), the silicon beam structure is partially consumed by the oxidation (lines 4-5, col. 7). By the assignee, the prior art for making the device in Fig. 1, see col. 10, is MacDonald USPN 5,375,033. Several patents to Chong et. al. USPN 6,180,536; 6,462,391 and 6,544,863 for microfabrication, the latter involving wafer bonding. Hofman et. al. USPN 6,767,614 teach the multiple level process,  $\text{CHF}_3$  is a known RIE etch but is typically used to etch the horizontal  $\text{SiO}_2$  floor, (lines 20-23, column 3, of USPN 6,767,614).

16. Regarding the use of  $\text{CHF}_3$ : examiner submits Moreau, Wayne, Semiconductor Lithography, Plenum, 1988, pp. 733-734. On page 733 it is clear that the plasma etch is substituted for the HF (wet) etch by the statement that [it] plasma [is used] "to mimic HF wet etch" (see parenthesis, third to last line, p.733). See also,  $\text{CHF}_3$  listed in the last line on p. 733; thus further on page 734, the listing of  $\text{CHF}_3$  in Table 13-13-17, has significant selectivity for  $\text{SiO}_2$



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to p-doped Si, while SF<sub>6</sub> is significant for Si to SiO<sub>2</sub>. The Bosch technology is apparently SF<sub>6</sub> (see Goldbach et. al. lines 41-44, column 1).

17. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Michael K. Luhrs whose telephone number is 571-272-1874. The examiner can normally be reached on M-F, 8-5.

18. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Richard T. Elms can be reached on 571-272-1869. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

19. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

  
Michael K. Luhrs  
12/29/04

  
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